

TEST OF AN END-FED UNELEVATED 1524-METER (5000-FOOT) WIRE ANTENNA

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Introduction

In the mid-1980s, the author discovered that simple, end-fed horizontal wire antennas at low heights or on the ground provided good mediumwave reception. This realization spurred him to test reception with similar antennas of various lengths up to 609.6 meters (2000 feet) at heights from 0 to 3.0 meters (0 to 10 feet) above the ground.

Unlike the Beverage or Beverage-on-ground designs, these antennas did not use a terminating resistor or ground connection at the far end or any type of impedance matching.

The author's purchase of 1524-meter (5000-foot) spools of industrial surplus wire provided an opportunity to deploy even longer unelevated wire antennas. Therefore, on 6 September 1987 (6 to 7 September UTC), the author and a colleague deployed and tested the receiving performance of an unelevated 1524-meter (5000-foot) long wire antenna in the California desert. A few years later, the author prepared a handwritten rough draft report of the test and set it aside. The manuscript was found in 2020 and subsequently converted to digital form, refined, and prepared for publication.

Objective

The primary objective of the test was to compare the performance of an unelevated end-fed 1524-meter-long wire antenna with similar 304.8 and 609.6-meter (1000 and 2000-foot) antennas the author tested previously. Of particular interest were the directivity and gain of a 1524-meter wire between 9 and 3000 kHz. The author also hoped the expected directivity and gain of the antenna would allow him to receive longwave and mediumwave stations he had not previously logged.

Test Site

The antenna test site was located at 34.6895° N and 118.3285° W or 16.9 kilometers (10.5 statute miles) west of Lancaster, CA city hall and 71.1 kilometers (44.2 statute miles) north of Los Angeles, CA city hall (Figure 1). The topography at the site consisted of broad, gently rolling low hills and shallow depressions. The ground was dry, hard, and had sparse vegetation. The site was chosen because its lack of interference from Los Angeles mediumwave broadcast stations, the large expanse of barren land, and its convenient location.

Radio Propagation

The test was conducted from local early afternoon to early evening during northern hemisphere late summer. Sunset occurred at the site at 19:13 PDT.

Receiving System

The receiving system for the test consisted of a primary antenna, comparison antenna, low-frequency converter, communications receiver, and digital demodulator.

Primary Antenna

The primary antenna was an unelevated 1524-meter length of 0.511-millimeter (24-AWG) diameter solid conductor wire with thick plastic insulation. A length of 1524-meters was used because it was the total amount of wire on the spool and it was significantly longer than similar antennas the author had previously tested.

The wire was unrolled from the spool and laid on the ground in a straight line that ran 115°/295° from true north (east-southeast to west-northwest). The original plan was to run the wire east to west to parallel the road near the receive site. After arriving at the site, the author decided to deploy the antenna away from the road at an angle to reduce the reception of motor vehicle ignition noise.

The end of the antenna farthest from the receiver was not grounded and the antenna was connected to the input of the receiving equipment without any type of impedance matching.

The weight of the wire made deploying the antenna a two-person task: one to hold the spool of wire and another to unreel the wire and lay it on the ground.

Comparison Antenna

The antenna testing was performed inside of an automobile with a mediumwave broadcast receiving system consisting of a vertical whip antenna and a factory-installed receiver. The vehicle's original whip antenna was replaced with an after-market center-loaded vertical whip to improve reception. In some instances, the 1524-meter wire was disconnected from the communications receiver and the automobile whip antenna was connected to compare their mediumwave performance.

Low-Frequency Converter

To overcome the communications receiver's lack of longwave sensitivity, a Palomar Engineers VLF converter was connected between the 1524-meter antenna and the receiver to up-convert 5 to 500 kHz signals to 4000 to 4500 kHz.

Communications Receiver

Antenna performance was evaluated using a Realistic DX-302 communications receiver. It featured a triple conversion, synthesized design, and received from 5 to 30000 kHz. The DX-302 was connected to the east-southeast end of the 1524-meter wire antenna.

Digital Demodulator

An Advanced Electronic Applications MBA-RO digital demodulator was brought to the site to convert the audio of Morse Code and teletype signals received with the DX-302 to text.

Ground

The communications receiver was not grounded during the test because the hardness of the ground would make driving a ground rod into the earth difficult. The author also doubted the site's assumed low soil conductivity could provide a good enough ground to improve reception. The only communications receiver ground connection was to the automobile body via the -12V power lead.

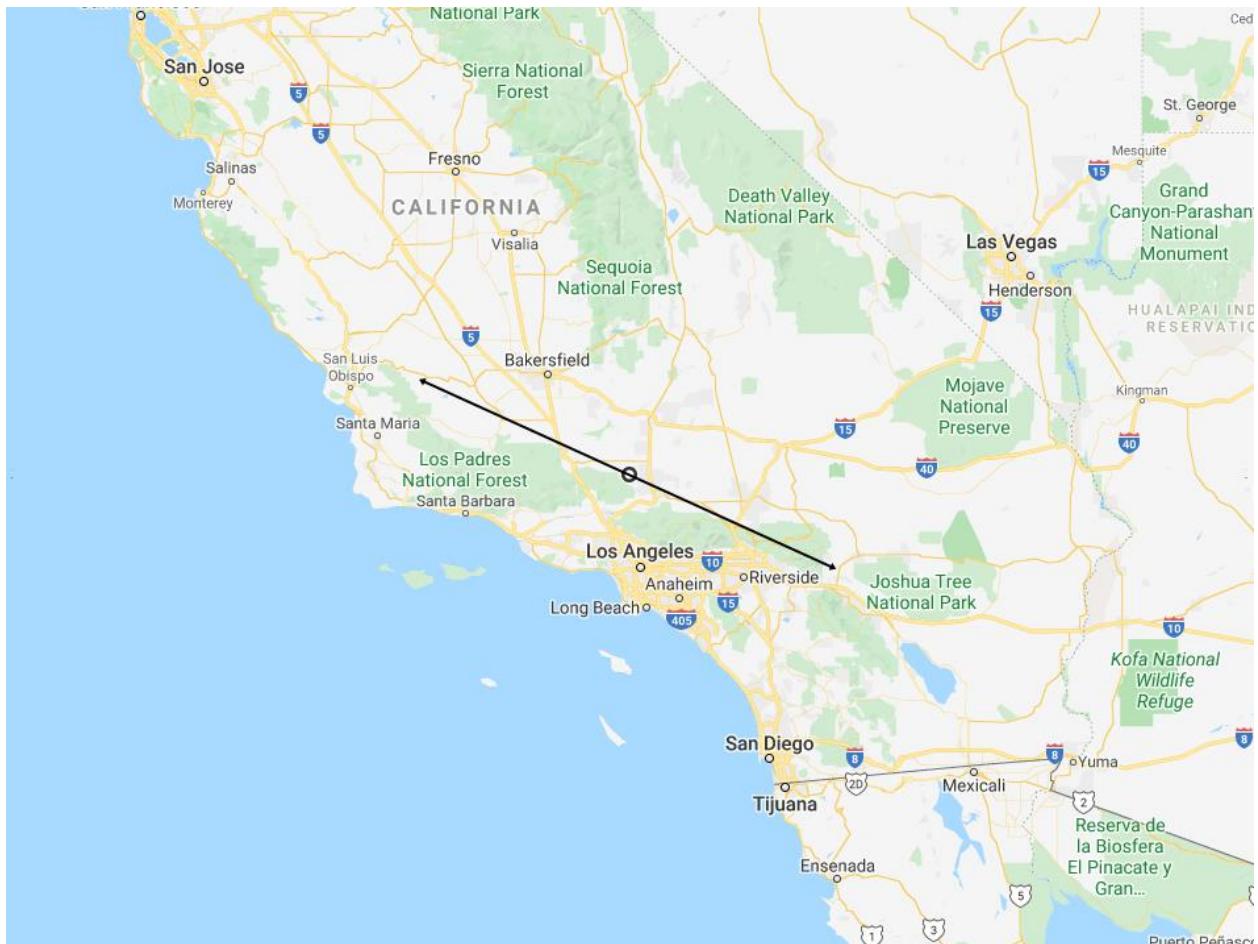


Figure 1. Test Site Location and Antenna Orientation (map courtesy of Google Maps)

Results

The 1524-meter antenna was tested on long-, medium-, and shortwave. As a result, 21 stations were logged including 17 which were previously unlogged. The results are summarized in Table 1.

When possible, the signal strength was measured in S-units using the receiver's signal strength meter. The meter had markings for 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, S-9 +10, and S-9 +30 S-units. A reading of S-0 represented no measurable signal strength while S-9 +30 corresponded to the maximum measurable signal strength. For simplicity, signal strengths above S-9 are listed as S-10, S-20, S-30, and so on. In other cases, the signal strength was assessed using a subjective term such as "weak."

Table 1. Summary of 1524-meter (5000-foot) Antenna Test Results

Time (PDT)	Freq. (kHz)	Signal Type	Callsign	Location	Range (km)	Power (W)	1524-meter Antenna		Auto Whip Antenna Signal Strength
							Signal Strength	Fading	
14:49-14:59	580	AM	KMJ	Fresno, CA	260	5000	S-15	None	-
15:05-15:11	860	AM	KTRB	Modesto, CA	410	50000	S-3.5 to S-4	3 fades per sec.	-
15:16-15:25	960	AM	KAVR	Apple Valley, CA	95	5000	S-9	None	-
15:29-15:41	1010	AM	KCHJ	Delano, CA	145	5000	S-15	None	-
15:48-15:54	1350	AM	KLYD	Bakersfield, CA	95	1000	S-10	None	-
15:55-16:06	1380	AM	KHJJ	Lancaster, CA	14	1000	S-30	None	S-10
16:29-16:34	1410	AM	KERN	Bakersfield, CA	95	1000	S-10	None	S-1.5
16:59-17:05	1230	AM	KGEO	Bakersfield, CA	95	1000	S-20	None	Less than S-2
17:31-17:41	1080	AM	KSCO	Santa Cruz, CA	420	10000	S-5	None	Near zero
18:04-18:10	106	RTTY	Unk	Unk	Unk	Unk	S-15	None	-
18:11-18:15	111	RTTY	Unk	Unk	Unk	Unk	S-10	-	-
18:17-18:20	162	RTTY	Unk	Unk	Unk	Unk	S-9.5	None	-
18:22-18:25	164	RTTY	Unk	Unk	Unk	Unk	S-9.5	None	-
18:26-18:33	167	RTTY	Unk	Unk	Unk	Unk	S-5.5	None	-
18:34-18:37	189	Multiplex	Unk	Unk	Unk	Unk	S-7	None	-
18:39-18:47	215	AM/MCW	HAK	Adelanto, CA	80	15	S-4.5	None	-
18:52-18:59	410	AM/MCW	NZJ	MCAS El Toro, CA	120	25	Weak	None	-
19:30-19:35	1490	AM	KRKCC	King City, CA	310	1000	S-20	Slow	Inaudible
20:19-20:28	415	AM/MCW	IEE	Platform Irene, CA	220	-	S-4.5	None	-
Late Afternoon	820	AM	WBAP	Fort Worth, TX	1973	50000	Readable	None	-
Late Afternoon	14996	AM	RWM	Moscow, USSR	9741	8000	Fair-Good	-	-

Hyphens (-) represent information that was not recorded or is unavailable or not applicable.

Signal Levels

An unexpected characteristic of the 1524-meter wire was that reception was possible with the antenna disconnected. After the antenna was deployed, the end of the wire was brought near the receiving equipment to connect it. Surprisingly, when the antenna was within 1.2 or 1.5-meters (4 or 5 feet) of the receiving equipment, it began receiving background noise! The closer the end of the antenna was brought to the receiving equipment, the stronger the noise.

Receiver overloading was expected on mediumwave because of the antenna's length. Surprisingly, the problem occurred on longwave rather than mediumwave. Signal levels below 500 kHz were so high that reception was impossible in that portion of the spectrum. To remedy the problem, the author coupled the 1524-meter antenna to the receiving equipment through a "gimmick" capacitor he improvised in the field (Figure 2).

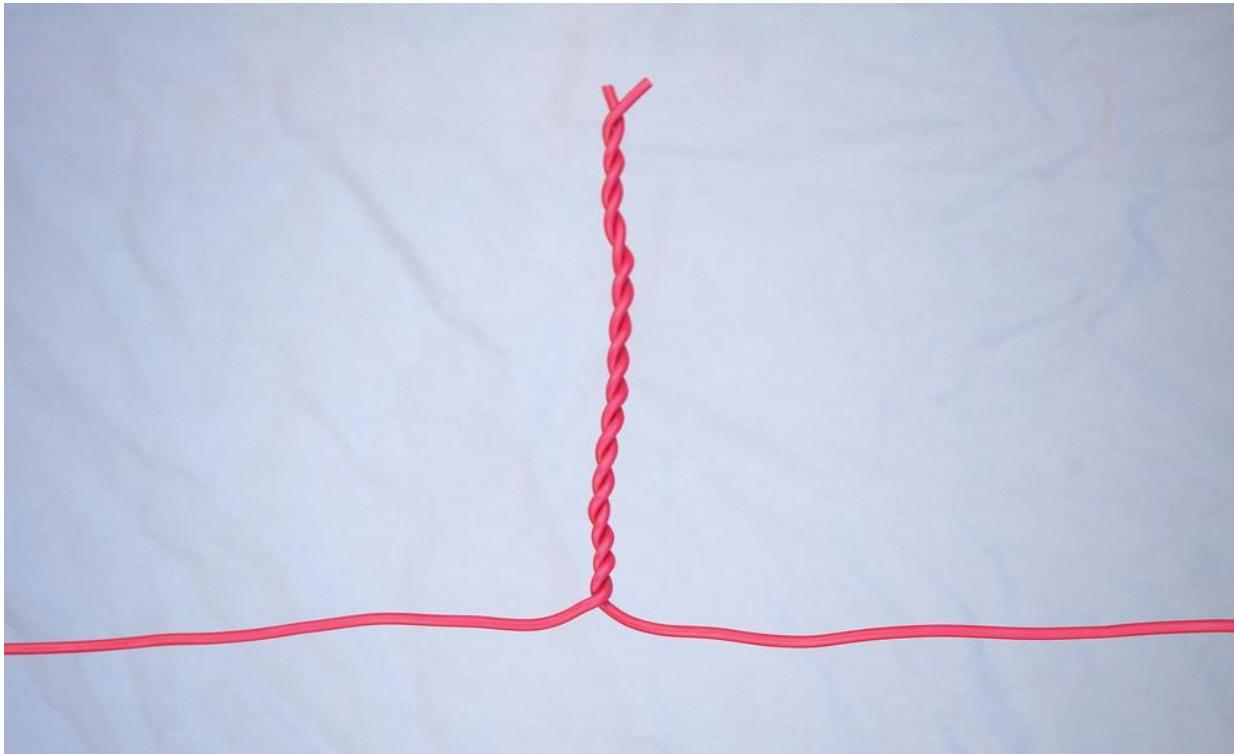


Figure 2. Gimmick (Improvised) Capacitor Example

The capacitor was made by cutting the antenna wire approximately 47.5 centimeters (18 inches) from where it connected to the receiving equipment. The wire connected to the receiving equipment and the end of the antenna were then twisted together until a satisfactory signal level was obtained.

Longwave

The antenna's overall performance on longwave was mixed. Reception from 9 to 200 kHz was good with four radioteletype (RTTY) and one multiplex station logged. The RTTY signals could not be converted to readable text.

The 200 to 450 kHz region featured few stations. Previous tests with unelevated 304.8 and 609.6-meter (1000 and 2000-foot) wire antennas produced very good results in this frequency range with numerous non-directional navigation beacons heard. The lackluster 200 to 450 kHz results with the 1524-meter

antenna were probably primarily due to the influence of the season and time of day on radio propagation.

Mediumwave

On mediumwave the 1524-meter antenna performed well. It provided good reception from many directions and appeared to have great gain in some instances compared to the auto whip comparison antenna. For example, KRKC from King City, CA was received on the 1524-meter wire with a strength of S-20 (very strong), but was inaudible on the vertical whip.

Another interesting characteristic of the 1524-meter wire on mediumwave was the lack of signal fading. For example, WBAP in Dallas Fort Worth, TX (820 kHz) was heard via long-range propagation that usually featured fading. However, on the 1524-meter wire, WBAP had a readable signal with no fluctuation in strength.

Nearly all mediumwave stations logged with the 1524-meter wire were along straight lines 27.5° and 45° off the antenna axis. Many stations came from the general direction of Bakersfield, Delano, Fresno, and Modesto, CA. This was probably due to the fact these cities were in the same general direction with respect to the test site.

The limited number of stations logged and the uneven distribution of broadcast stations in North America make it difficult to conclude the lines are an indication of the antenna's mediumwave directivity.

Shortwave

Although the 1524-meter wire was deployed for testing below 3000 kHz, a cursory check of its performance was made on shortwave where it appeared to exceed the performance of shorter, elevated wires. From 14350 to 15000 kHz, for example, numerous utility stations were heard including a time signal station on 14996 kHz. It was heard earlier in the day and was stronger on the 1524-meter wire than on shorter, elevated wire antennas the author used previously at other locations.

Conclusions

The test, while limited, indicated the 1524-meter-long wire antenna offered good reception in sections of the radio spectrum.

It exhibited good 9 to 200 kHz performance but mediocre 200 to 450 kHz reception. On mediumwave the 1524-meter wire performed well. In one case it received a signal that was inaudible on the auto whip comparison antenna. Compared to other antennas, mediumwave signals received with the 1524-meter wire seemed to have less fading. The limited testing and uneven geographic distribution of mediumwave stations made the antenna's mediumwave directivity difficult to determine.

On shortwave, the 1524-meter wire appeared to exceed the performance of shorter, elevated wire antennas the author had used elsewhere.

Receiver frontend overloading was a problem that could be mitigated by using a receiver with better frontend performance and a built-in attenuator. If necessary, an external attenuator could be placed between the antenna and low-frequency converter or receiver.

Future testing should also use wire with thinner insulation to reduce the wire's weight and allow it to fit on a smaller spool. This would make deploying and retrieving the wire easier and eliminate the need for help from a second person.

To better characterize the performance of this antenna, further testing will be required, preferably from the same general location. Testing should be conducted in late autumn to early winter to determine if the antenna's lackluster 200 to 450 kHz performance was the result of late summer radio propagation. Also, different orientations should be tried to better characterize the antenna's mediumwave pattern. For example, the antenna could be oriented to place New York City and the northeastern U.S. in the expected direction of best reception.

Glossary

AM	Amplitude modulation
ASCII	American Standard for Computer Information Interchange. A digital communications mode.
AWG	American Wire Gauge
CA	California
Freq.	Frequency
kHz	Kilohertz
km	Kilometers
Longwave	For the purposes of this paper, the radio spectrum below 500 kHz
MCAS	Marine Corps Air Station
MCW	Modulated Continuous Wave
Mediumwave	For the purposes of this paper, the radio spectrum between 500 and 1800 kHz
Multiplex	In this case, a radio signal with multiple teletype or other non-voice signals
N	North latitude
PDT	Pacific Daylight Time (UTC -7 hours). The local time at the antenna test site.
Platform Irene	An oil production platform in the Pacific Ocean near Santa Barbara, CA
RTTY	Radioteletype
S-	Signal strength units
sec.	Second
Shortwave	For the purposes of this paper, the radio spectrum between 1800 and 30000 kHz
TX	Texas
Unk	Unknown
USSR	Union of Soviet Socialist Republics
UTC	Coordinated Universal Time (PDT +7 hours)
Utility Station	A radio station whose transmissions are not intended for reception by the general public (for example, navigation signals, maritime communications, time signals, and so on)
V	Volt
VLF	Very Low Frequency
W	West longitude or transmitter power in watts